Hess's Law part 2:

Standard energy of formation:

ex: $C_{(s)} + O_{2(g)} \rightarrow 1CO_{2(g)}$

elements in standard conditions — compound is formed

$H_{2(g)} + \frac{1}{8}S_{8(s)} + 2O_{2(g)} \rightarrow 1H_2SO_{4(l)}$

Given as: $\Delta H^\circ_f\ CO_{2(g)} = -393.5\ kJ/mol$

p597 Table E.8

Reactants → Products $\Delta H^\circ = ?$

$\Delta H^\circ = \sum \Delta H^\circ_f \text{ products} - \sum \Delta H^\circ_f \text{ Reactants}$ (∑ = sum of)

$2CO_{2(g)} + H_2O_{(g)} \rightarrow 1C_2H_{2(g)} + \frac{5}{2}O_{2(g)}$ ($\Delta H^\circ_f = 0$)

$\Delta H^\circ = [1 \times \Delta H^\circ_f\ C_2H_{2(g)}] - [2\ \Delta H^\circ_f\ CO_{2(g)} + 1\Delta H^\circ_f\ H_2O_{(g)}]$

(+227.4 kJ/mol, −393.5, −241.8)

$= 227.4 - [2(-393.5) + (-241.8)]$

$= 1256.2\ kJ$

$2C_{(s)} + 2O_{2(g)} \rightarrow 2CO_{2(g)} + 393.5\ kJ$ (×2)

$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(g)} + 241.8\ kJ$

$2C_{(s)} + H_{2(g)} + 227.4\ kJ \rightarrow C_2H_{2(g)}$

$\Delta H^\circ_f\ C_2H_2 = +227.4\ kJ/mol$

Things to watch out for:

ΔH°_f : formation of a compound from the elements in standard state

ΔH°_f elements in standard form = 0

ex: $\Delta H^\circ_f\ I_{2(s)} = 0$

$\Delta H^\circ_f\ I_{2(l)} \neq 0$

Handout P254

Elements in standard form:

$Na_{(s)}$, $Br_{2(l)}$, $P_{4(s)}$, $S_{8(s)}$

Pay attention to the physical states of substances

use mole coefficients when determining ΔH°_f need a balanced equation.

Feb 14-1:22 PM

Question 1:

Combustion of methane:

$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$

$\Delta H^\circ_{\text{Combustion } CH_4} \Rightarrow$ using ΔH°_f

$\Delta H^\circ_{comb} = [1 \times \Delta H^\circ_f CO_{2(g)} + 2\,\Delta H^\circ_f H_2O_{(g)}] - [1 \times \Delta H^\circ_f CH_{4(g)} + 2 \times \Delta H^\circ_f O_{2(g)}]$

(−393.5) (−241.8) (−74.6) 0

$= [2(-241.8) + (-393.5)] - (-74.6)$

$= -802.5$ kJ/mol

$Q_{water} = mc\Delta T$

$= (300\,000)\text{g} \times 4.18 \text{ J/g°C} \times 52.5°\text{C}$

$= 65835000$ J

$= 65835$ kJ

$Q_{sys} = -Q_{surr}$

$\dfrac{1 \text{ mol } CH_4}{-802.5 \text{ kJ}} = \dfrac{x \text{ mol } CH_4}{-65835}$

or $\dfrac{Q}{n} = \Delta H$ (Q → kJ, n → mol, ΔH → kJ/mol) $n = \dfrac{\Delta H}{Q}$

or $n = \dfrac{Q}{\Delta H} \Rightarrow \dfrac{-65835 \text{ kJ}}{-802.5 \text{ kJ/mol}}$

$n = 82.04$ mol

$m = n \times M$

$= 82.04 \text{ mol} \times 16.04 \text{ g/mol}$

$= 1316.7$ g

$= 1.32$ kg

or $\dfrac{82.04 \text{ mol}}{x \text{ g}} = \dfrac{1 \text{ mol}}{16.04 \text{ g}}$

Feb 14-2:04 PM